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BIOMASS ESTIMATION FOR SOME SHRUBS FROM NORTHEASTERN MINNESOTA

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ABSTRACT.--Biomass prediction equations were developed for 23 northeastern Minnesota shrub species. The allometric function was used to predict leaf, current annual woody twig, stem, and total woody biomass (dry grams), using stem diameter class estimated to the nearest 0.25 cm class at 15 cm above ground level as the independent variable.

OXFORD: 182.46:182.5(776). KEY WORDS: wildlife habitat, nonlinear regression analysis, allometric relations, dry weight, browse estimation.

A recent study (unpublished) to quantitatively describe a series of pine plantations in northeastern Minnesota as white-tailed deer and snowshoe hare habitat placed special emphasis on woody plants as potential browse. The descriptive information included shrub density and basal area. To estimate the browse represented by these data, equations were needed to determine the biomass of leaf and current annual woody-twig growth for each species. Reported here are the data collected and the resulting regression equations developed to produce the needed estimates. These equations should be useful to land managers, game managers, and other researchers who need to estimate biomass values for these species within the northern Lake States region.

For each of the major shrub species found in the plantations, stems spanning the size range were collected during the last half of August 1976. In the plantation study, shrub diameters had been determined to the nearest 0.25 cm at 15 cm above ground level. In sampling for the biomass estimation equations, we attempted to collect individuals from the lowest, highest, and middle size class for each species. Thus, if a species occurred in the study in size classes 1 (0 to 0.25 cm) through 7 (1.50 to 1.75 cm), we selected a minimum of three typical stems within each of three size classes spanning that range: for example, size class 1, 4 (0.75 to 1.00 cm), and 7. For shrubs with small diameters, such as Rosa blanda, we selected only stems within the lowest three size classes.

The stems were selected in the field, clipped at ground level, and taken to the laboratory where the leaves and current annual woody-twig growth were each separated from the remainder of the woody stem. Each component of each stem was bagged separately and dried at 70 C to constant weight. Each component was weighed to the nearest 0.01 gram immediately after removal from the oven.

Because of dry weather during the summer of 1976, some shrub stems had lost a portion of their leaves by late August. In those cases no leaf data were collected and the number of leaf biomass observations used in the leaf biomass regressions was reduced.

The independent variable, stem diameter size class; and each dependent variable-leaf,

current annual woody-twig, stem, and total woody biomass were summarized for each species (table 1).

The numerical value used for stem diameter was the upper end of the diameter class range. Stems 0.50 to 0.75 cm diameter, for example, were considered to be 0.75 cm diameter in the data summary.

In earlier work estimating biomass of five shrub species from northeastern Minnesota, we found that shrub biomass data conformed to the allometric function as well as or better than they did to alternative functional relations (Ohmann, Grigal, and Brander 1976)[1].

[1]*Ohmann, L. F., D. F. Grigal, and R. B. Brander. 1976. Biomass estimation for five shrubs from northeastern Minnesota. USDA For. Serv. Res. Pap. NC-133, 11 p. North Cent. For. Exp. Stn., St. Paul, MN 55108.*

Table 1.--*Dimensional data for*

	Acer rubrum	*Acer spicatum*	*Alnus crispa*	*Alnus rugosa*	*Amelanchier* spp.	*Betula papyrifera*	*Cornus rugosa*	*Corylus cornuta*	*Lonicera canadensis*	*Lonicera hirsuta*	*Lonicera* obl
Independent variable											
Stem diameter class (cm)	---										
Number of observations	10	27	26	15	27	10	9	43	9	13	4
Mean	1.17	1.17	1.14	.90	1.17	1.23	1.00	1.08	.75	.69	
Standard deviation	.51	.52	.52	.53	.52	.55	.43	.53	.43	.27	
Standard error	.16	.10	.10	.14	.10	.17	.14	.08	.14	.38	
Range	.50-1.75	.50-1.75	.50-1.75	.50-1.75	.50-1.75	.50-1.75	.50-1.50	.50-1.75	.25-1.25	.25-1.00	
Dependent variables											
Leaf biomass (dry grams)	---										
Number of observations		11	25	12	14	4	9	9	4	10	4
Mean		4.33	9.51	6.04	8.62	3.11	11.41	15.46	2.33	2.34	
Standard deviation		11.79	9.18	8.64	6.75	4.33	10.35	15.75	1.52	2.86	
Standard error		3.56	1.84	2.49	1.80	2.16	3.45	5.25	.76	.91	
Range		.01-39.44	.07-27.00	.15-29.08	.05-19.95	.62-9.57	1.32-27.17	.11-36.21	.16-3.68	.18-9.29	
Current annual twig (dry g)											
Number of observations	10	27	26	15	27	10	9	43	9	13	4
Mean	1.04	2.48	2.73	5.02	2.31	4.34	2.42	2.76	.97	1.15	
Standard deviation	.72	2.49	3.31	6.31	2.52	6.85	2.03	2.92	.92	1.36	
Standard error	.23	.48	.65	1.63	.49	2.17	.68	.45	.31	.38	
Range	.10-2.39	.12-10.83	.18-12.67	.36-19.80	.01-8.26	.51-23.23	.25-5.58	.12-10.30	.06-2.50	.06-4.62	
Stem (dry grams)											
Number of observations	10	27	26	15	27	10	9	43	9	13	4
Mean	69.62	87.99	78.69	43.38	89.39	76.30	48.18	88.23	19.49	19.24	
Standard deviation	73.00	87.81	77.76	63.38	84.50	81.78	50.14	102.96	19.69	22.14	
Standard error	23.09	16.90	15.25	16.36	16.26	25.86	16.71	15.70	6.56	6.14	
Range	.81-207.11	.34-345.90	.34-268.00	.36-171.40	.48-258.72	.51-247.69	1.30-131.57	.57-380.75	.27-52.52	.20-65.20	
Total woody (dry grams)											
Number of observations	10	27	26	15	27	10	9	43	9	13	4
Mean	70.66	90.47	81.41	48.39	91.70	80.65	50.60	91.00	20.46	20.39	
Standard deviation	73.50	89.10	78.74	68.93	86.07	83.38	52.12	105.66	20.54	23.02	
Standard error	23.24	17.15	15.44	17.80	16.56	26.37	17.37	16.11	6.85	6.38	
Range	.94-208.19	.66-351.90	1.05-271.00	.72-181.37	.96-259.83	1.02-251.62	1.55-137.15	.60-391.05	.54-54.86	.27-66.98	

Table 2.--*Regressions for estimation of biomass of*

Regression factors on stem diameter class (cm) (X)	*Acer rubrum*	*Acer spicatum*	*Alnus crispa*	*Alnus rugosa*	*Amelanchier* spp.	*Betula papyrifera*	*Cornus rugosa*	*Corylus cornuta*	*Lonicera canadensis*	*Lonicera hirsuta*	*Lonicera* obl
Leaf biomass (dry grams) (Y)	---										
a		2.869	5.650	3.123	5.432	3.421	8.616	4.808	6.592	3.926	
b		3.669	2.222	3.071	2.008	1.838	2.541	3.571	2.681	1.163	
R^2		.608	.748	.718	.875	.990	.940	.991	.901	.242	
S y.x		7.788	4.706	4.815	2.486	.524	2.701	1.568	.586	2.644	
Probability of larger F value		.005	.005	.005	.005	.010	.005	.005	.100	NS	
Current annual woody twig biomass (dry g)											
a	0.7676	2.174	2.349	4.122	1.510	.588	1.813	1.196	1.325	1.974	
b	1.4903	1.008	1.119	2.318	1.870	4.802	2.478	3.070	1.866	1.571	
R^2	.724	.260	.196	.815	.426	.282	.946	.774	.801	.281	
S y.x	.4021	2.186	3.028	2.815	1.947	6.155	.506	1.406	.440	1.208	
Probability of larger F value	.005	.010	.025	.005	.005	NS	.005	.005	.005	.100	
Stem biomass (dry grams)											
a	21.0780	41.074	37.137	27.452	36.439	22.260	30.648	36.858	26.766	44.156	
b	3.6892	2.706	2.772	3.122	2.995	3.452	3.184	3.272	2.180	3.578	
R^2	.908	.779	.845	.985	.922	.717	.955	.845	.930	.684	
S y.x	23.5026	42.107	31.242	8.069	24.132	46.119	11.340	41.061	5.566	13.006	
Probability of larger F value	.005	.005	.005	.005	.005	.005	.005	.005	.005	.010	
Total woody biomass (dry grams)											
a	21.7300	43.660	39.684	31.328	37.909	22.865	32.421	38.031	28.090	46.002	
b	3.6535	2.630	2.696	3.050	2.963	3.502	3.152	3.267	2.166	3.402	
R^2	.911	.778	.855	.991	.924	.764	.957	.847	.931	.678	
S y.x	23.3043	42.776	30.571	6.824	24.158	42.982	11.590	41.881	5.759	13.635	
Probability of larger F value	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	

[1]*All the woody growth was determined to be current annual. Stem and total woody biomass regressions were identical to current twig.*

In this study, then, the data for each species-variable combination were subjected to an iterative nonlinear, least squares regression analysis using the allometric relation

$$Y=aX^{b} \quad (1)$$

where Y is the biomass in grams dry weight of the dependent variable and X is the shrub diameter in cm at 15 cm above ground. The regressions were tested for significance using a standard F-test.

The resultant equation elements are presented in table 2.

species from northeastern Minnesota

opulus remuloides	Prunus pensylvanica	Prunus virginiana	Rhamnus alnifolia	Ribes spp.	Rosa acicularis	Rosa blanda	Rubus parviflorus	Rubus strigosus	Salix spp.	Sorbus americana	Viburnum rafinesquianum
28	9	9	6	9	8	9	9	11	9	9	9
1.14	1.17	.75	1.08	.50	.53	.50	.50	.48	1.17	1.17	1.00
.53	.54	.43	.49	.22	.21	.22	.22	.21	.54	.54	.43
.10	.18	.14	.20	.07	.07	.07	.07	.06	.18	.18	.14
.50-	.50-	.25-	.50-	.25-	.25-	.25-	.25-	.25-	.50-	.50-	.50-
1.75	1.75	1.25	1.75	.75	.75	.75	.75	.75	1.75	1.75	1.50
14	3	4	6	9	8	9	9	11	9	3	8
6.77	.68	2.33	5.66	.30	1.06	1.07	1.17	.87	15.57	.26	11.08
9.81	.43	1.52	6.21	.34	.73	1.10	1.04	1.09	16.49	.40	12.27
2.62	.25	.76	2.54	.11	.26	.37	.35	.33	5.50	.23	4.34
.16-	.26-	.16-	.32-	.08-	.24-	.14-	.10-	.10-	.37-	.01-	.46-
25.37	1.11	3.68	17.24	1.14	2.19	3.69	3.17	3.64	43.28	.72	33.96
28	9	9	6	9	8	9	9	11	9	9	9
1.92	2.57	.97	1.91	.11	.48	.64	1.41	.15	2.08	3.41	2.60
1.80	1.80	.92	2.06	.09	.44	.61	1.40	.13	1.83	4.16	3.30
.34	.60	.31	.84	.03	.16	.20	.47	.04	.61	1.39	1.10
.19-	.72-	.06-	.11-	.01-	.12-	.09-	.07-	.03-	.46-	.01-	.20-
6.38	6.13	2.50	5.23	.23	1.28	1.78	3.62	.48	5.72	11.73	9.48
28	9	9	6	9	8	9		11	9	9	9
5.50	97.74	75.67	51.91	2.59	2.54	3.32	---	1.17	109.34	83.60	82.89
3.51	89.27	68.67	54.01	3.64	2.36	4.13		1.61	131.46	99.72	95.10
3.89	29.76	22.89	22.05	1.21	.83	1.38		.49	43.82	33.24	31.70
.42-	1.19-	.70-	1.10-	.09-	.24-	.18-		.08-	.64-	.30-	1.45-
4.69	247.12	185.79	139.82	10.69	6.56	10.42		5.39	351.67	269.03	222.19
28	9	9	6	9	8	9	9	11	9	9	9
7.42	100.31	78.78	53.82	2.70	3.03	3.96	2.81	1.32	111.42	87.01	85.49
4.79	90.42	71.49	56.06	3.71	2.74	4.69	2.80	1.73	133.21	103.07	98.01
4.13	30.14	23.83	22.89	1.24	.97	1.56	.93	.52	44.40	34.36	32.67
.84-	2.38-	.71-	1.21-	.16-	.36-	.36-	.14-	.16-	1.28-	.31-	1.85-
9.04	251.57	193.49	145.05	10.92	7.84	12.20	7.24	5.87	357.39	278.12	231.67

from northeastern Minnesota (allometric relation $Y=aX^{b}$

opulus remuloides	Prunus pensylvanica	Prunus virginiana	Rhamnus alnifolia	Ribes spp.	Rosa acicularis	Rosa blanda	Rubus parviflorus	Rubus strigosus	Salix spp.	Sorbus americana	Viburnum rafinesquianum
2.227	4.947	7.953	2.009	1.513	3.286	4.160	4.595	7.081	4.514	2.885	8.526
4.258	2.836	1.954	3.835	3.023	2.004	2.302	2.376	3.871	3.692	3.454	3.007
.963	.000	.900	.881	.549	.879	.597	.720	.748	.894	.000	.951
1.956	.601	3.522	2.394	.245	.275	.745	.586	.577	5.735	.560	2.925
.005	NS	.005	.010	.025	.005	.025	.005	.005	.005	NS	.005
.894	2.095	1.516	1.040	.321	1.671	2.230	8.214	.491	.545	.841	1.096
2.501	1.037	2.605	2.885	1.719	2.312	2.078	3.283	1.498	3.690	4.023	4.362
.430	.257	.837	.808	.604	.513	.568	.957	.332	.787	.717	.766
1.382	1.654	1.317	1.011	.059	.333	.429	.312	.110	.902	2.366	1.707
.005	NS	.005	.025	.025	.050	.025	.005	.100	.005	.005	.005
3.718	48.927	34.049	29.929	32.958	12.890	30.900	---[1]	10.782	17.344	13.177	38.820
2.876	2.545	2.708	2.760	5.458	3.162	4.519		4.111	4.939	4.393	4.125
.914	.950	.856	.874	.776	.908	.873		.745	.923	.917	.981
2.024	21.366	27.863	21.452	1.843	.773	1.570		.857	39.009	30.800	14.172
.005	.005	.005	.010	.005	.005	.005		.005	.005	.005	.005
4.502	49.916	35.575	30.971	32.001	14.527	31.182	---[1]	11.519	17.815	13.982	39.921
2.874	2.547	2.704	2.764	5.256	3.042	4.074		4.032	4.919	4.900	4.132
.914	.952	.861	.872	.780	.878	.844		.734	.923	.922	.981
2.316	21.233	28.520	22.456	1.861	1.035	1.979		.938	39.551	30.738	14.504
.005	.005	.005	.010	.005	.005	.005		.005	.005	.005	.005

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